Title: “Post Flight Analysis of Optical Specimens from MISSE7”

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Abstract: More than 100 optical specimens were flown on the MISSE7 platform. These included bare substrates in addition to coatings designed to exhibit clearly defined or enhanced sensitivity to the accumulation of contamination. Measurements were performed using spectrophotometers operating from the UV through the IR as well as ellipsometry. Results will be presented in addition to discussion of the best options for design of samples for future exposure experiments.

Post Flight Analysis of Optical Specimens from MISSE 7

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Outline

M7 mission

Design

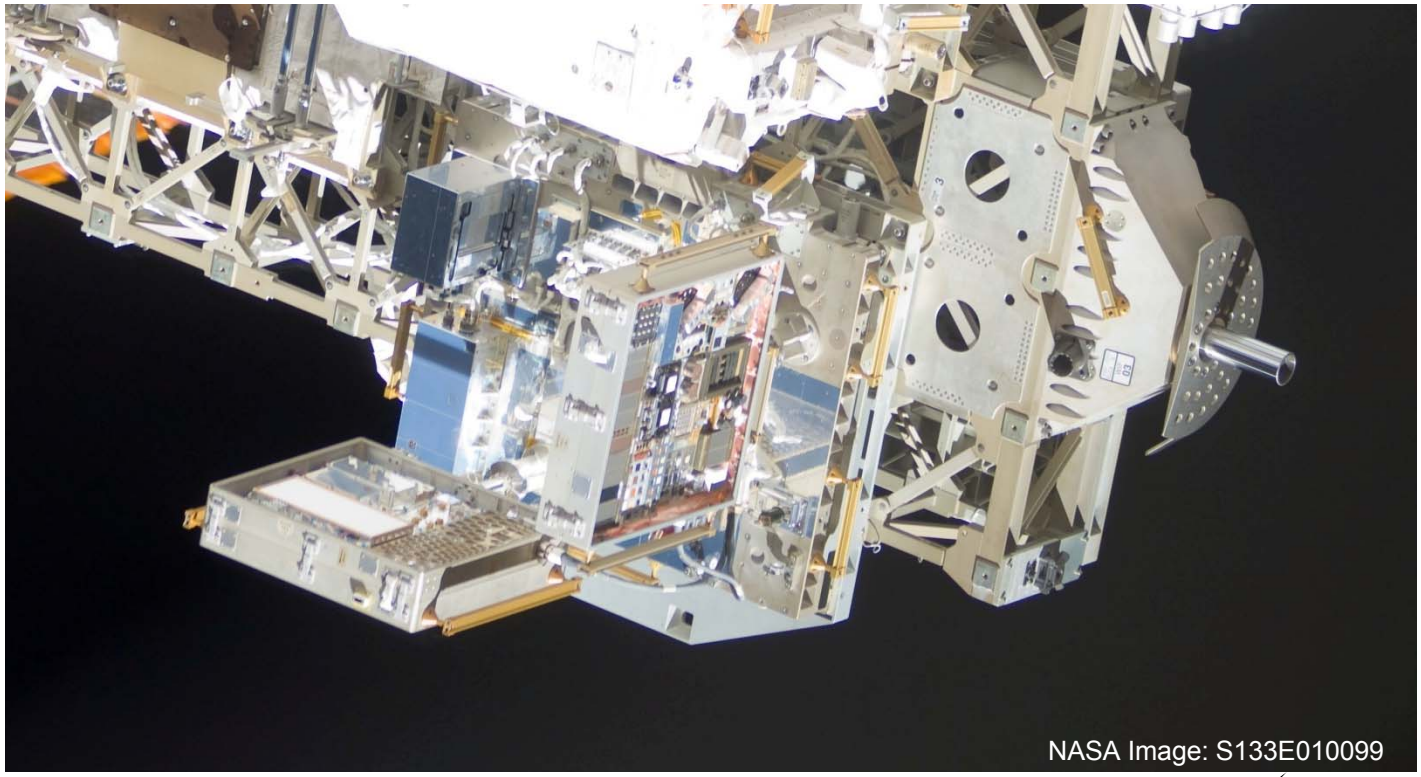
Samples

Performance

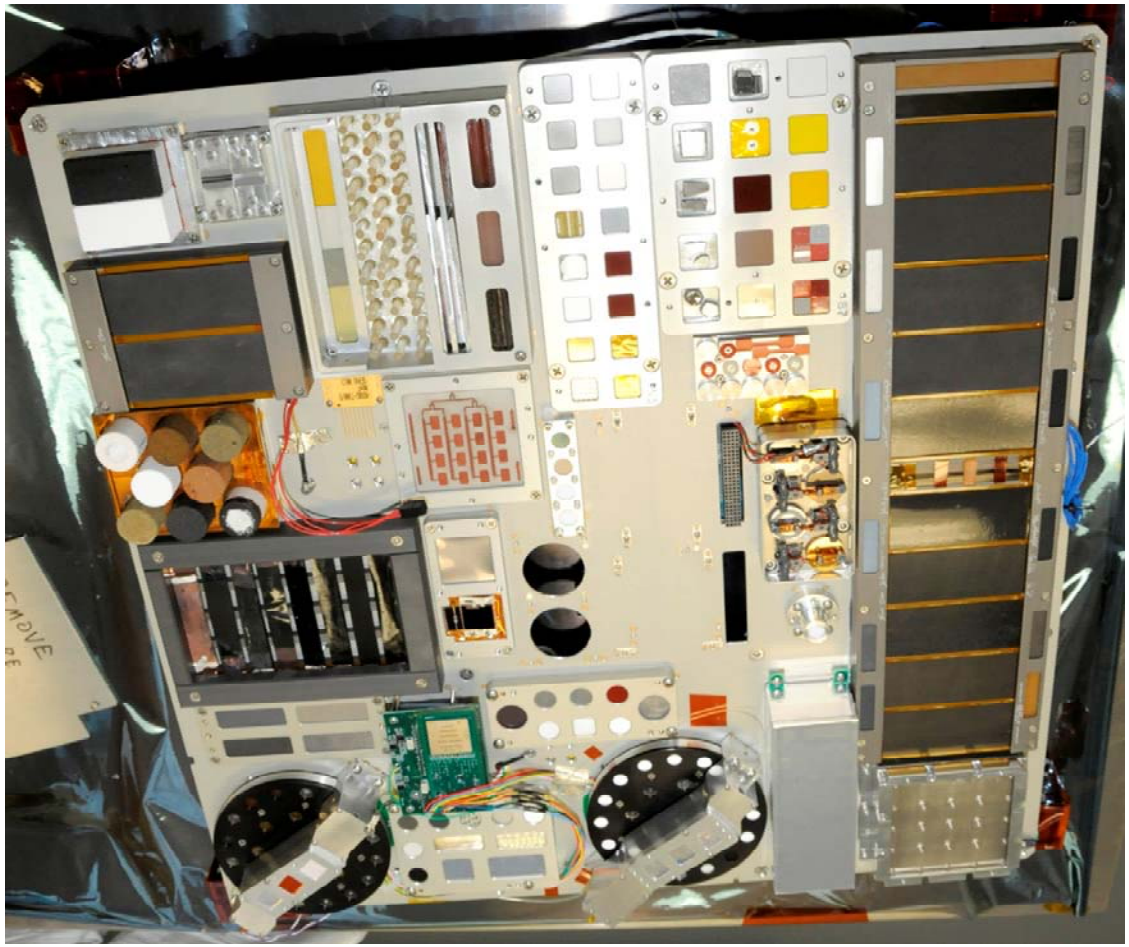
Summary

MISSE 7 Mission Objectives

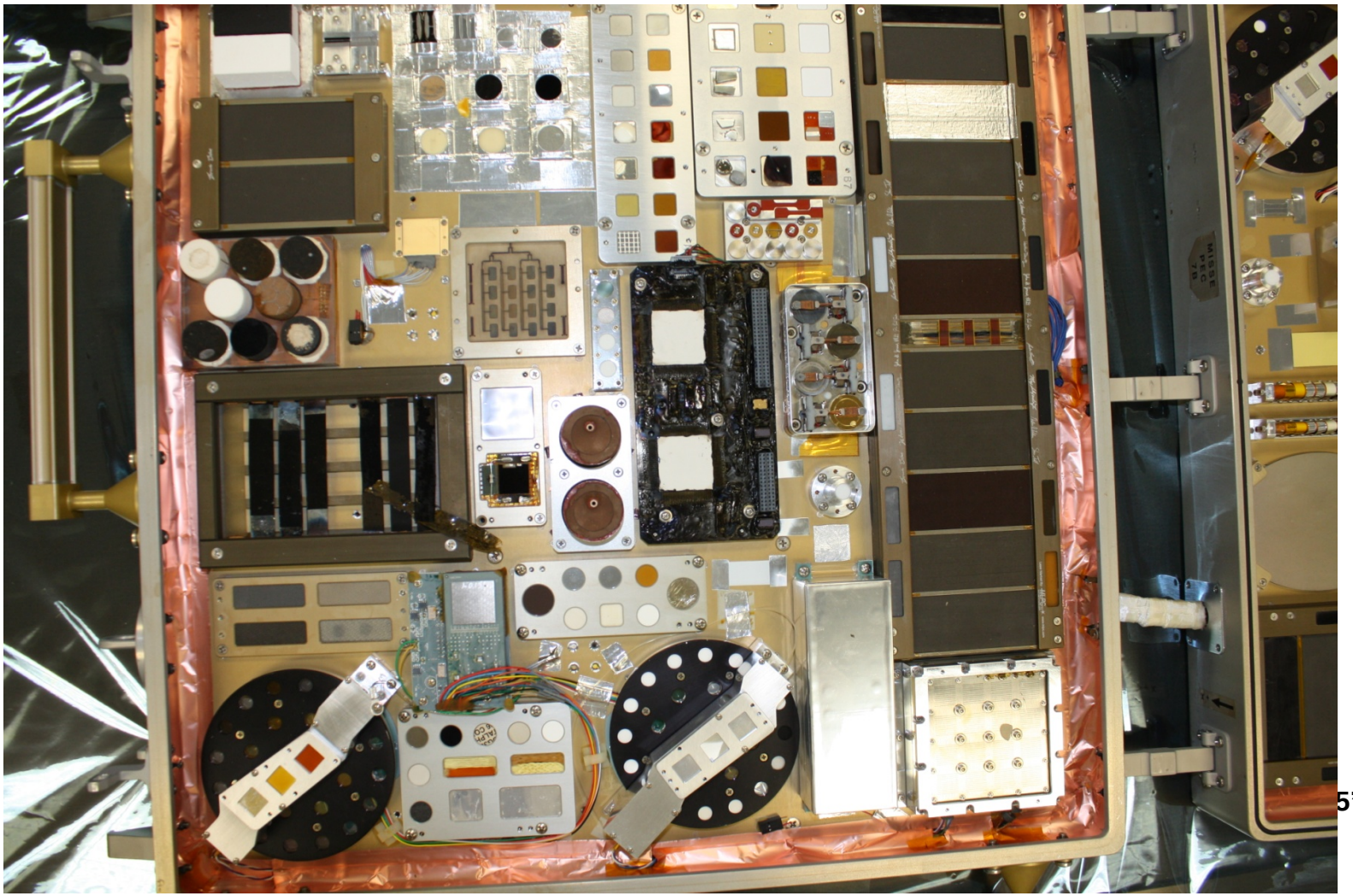
Deployed: 11/2009 and recovered 5/2011
PECs installed on the ISS Express Logistics Carrier
- space environment exposure experiments with power, control and telemetry


NASA Image: S133E010099

MISSE 7B PEC RAM Side Pre-flight

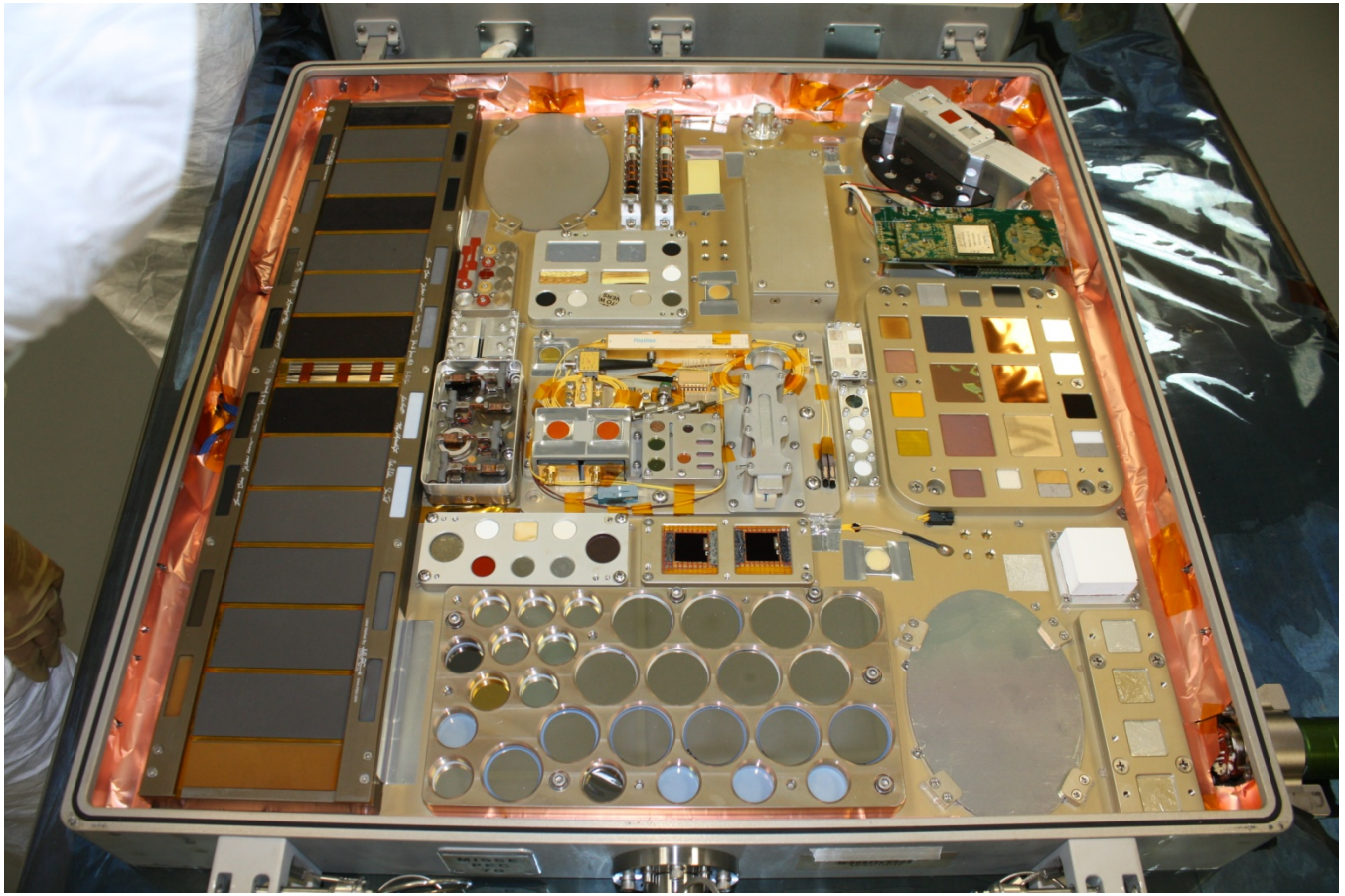


MISSE 7B PEC RAM Side Post-recovery



5”

MISSE 7B PEC Wake Side Post-recovery



MISSE 7B PEC Post Recovery

All spectrometer components and optical samples appeared to be in excellent condition

Location of spectrometer carousels – there was a slight rotation from designated “0” index point

After comparing
1. Images before and after flight
2. Data from the samples

– spectrometer carousels probably were never activated during mission

Passive exposure was the fallback mission for these samples

Potential comm and control problems were apparent before launch
PEC 7B was powered down during the mission due to an increase in current load and some elevated temperatures

Optical System Components

All spectrometer components were tested after de-integration and found to be in good working condition.

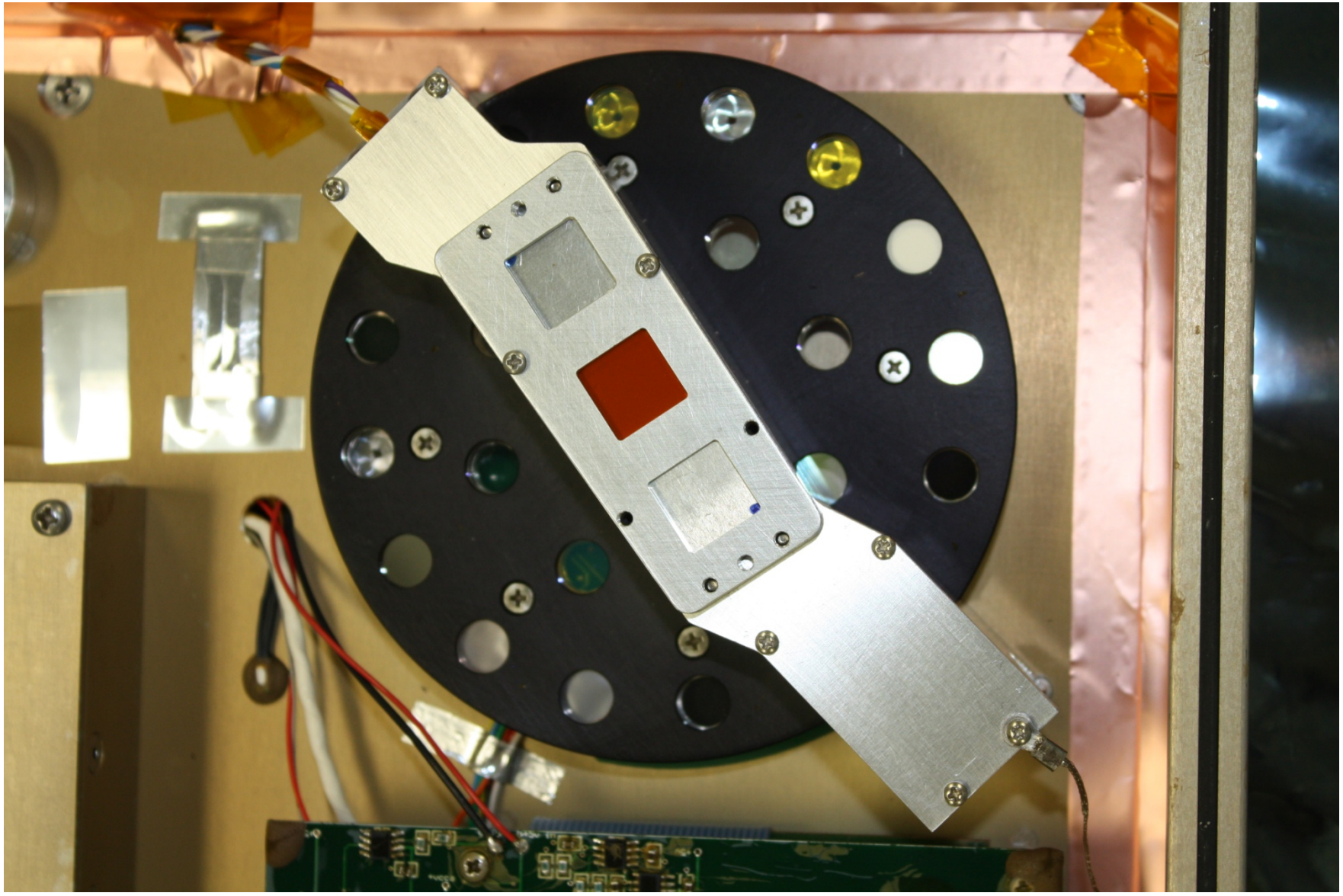
Optical fibers were all multimode fused silica, single and bifurcated
Spectrometers were Stellarnet “Blue Wave”

Calibration of system radiometric throughput was not performed before or after flight

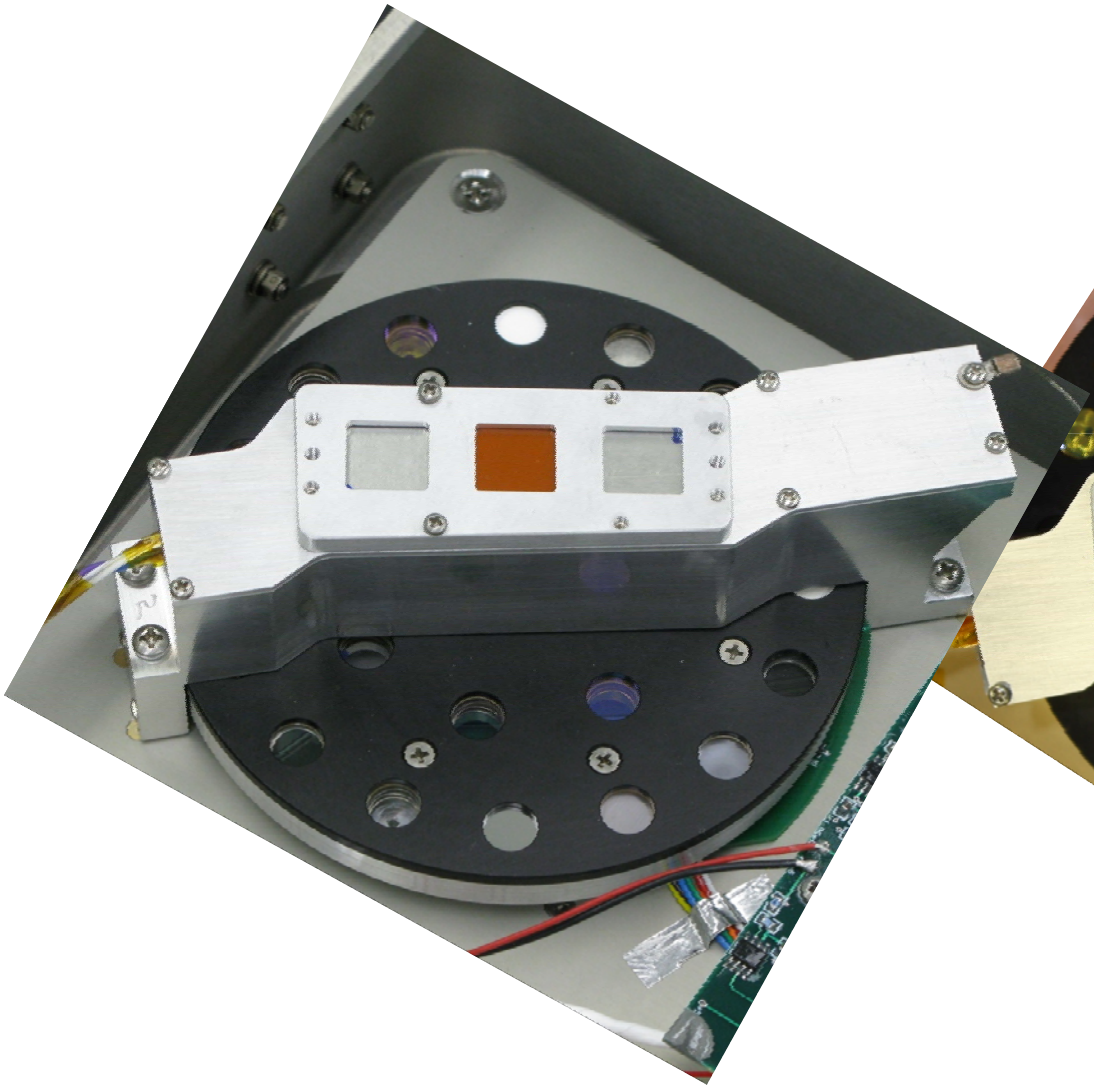
Mission plan:

Pre- and post-flight measurements on the ground
Comparison to “standards” on the carousels in flight

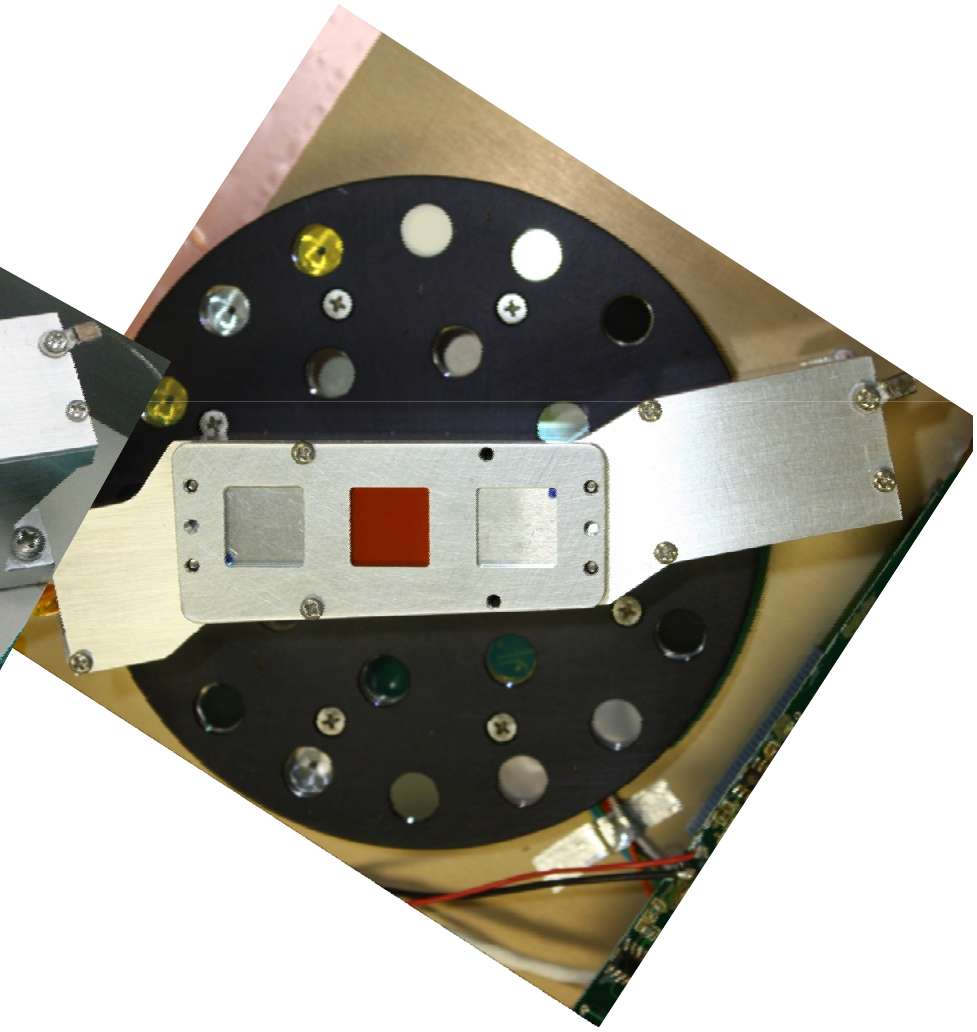
Wake



Wake

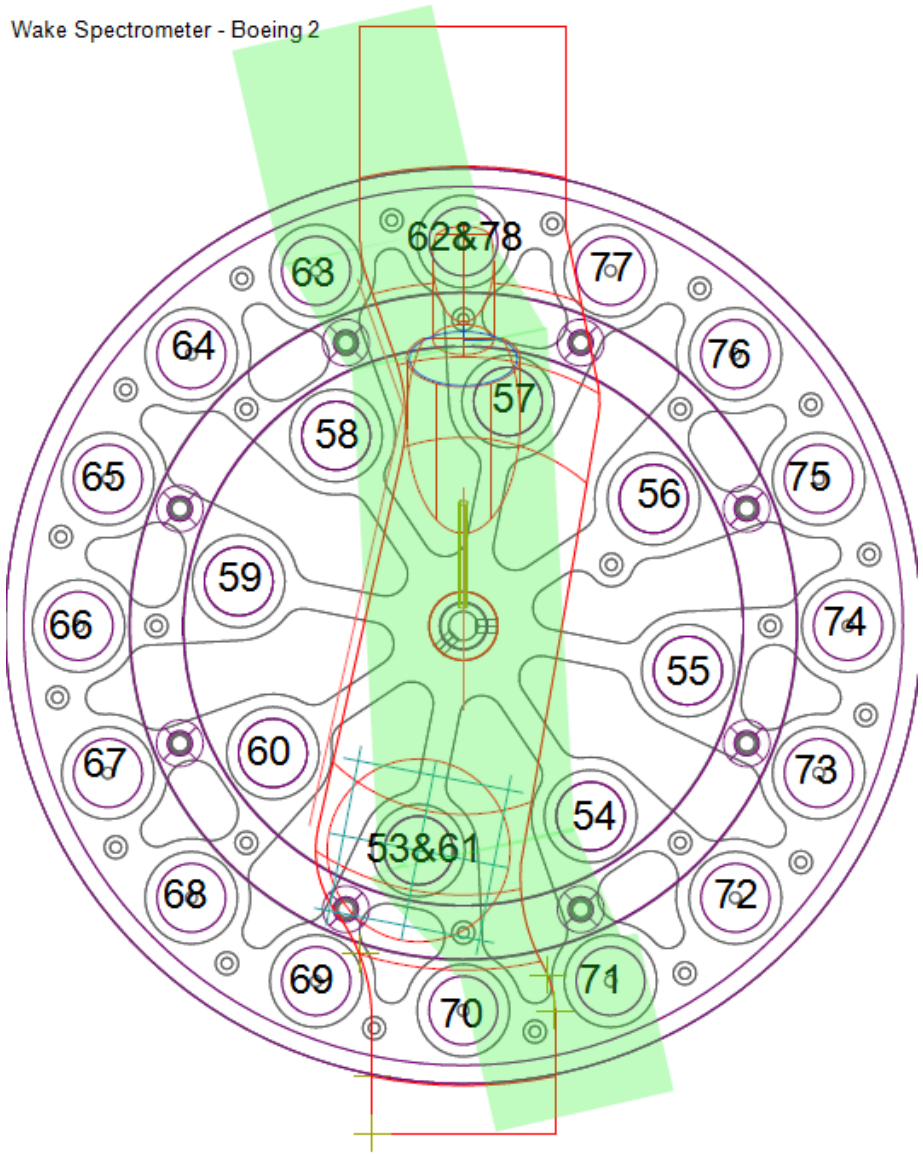


Following Vibe test



Post-Flight

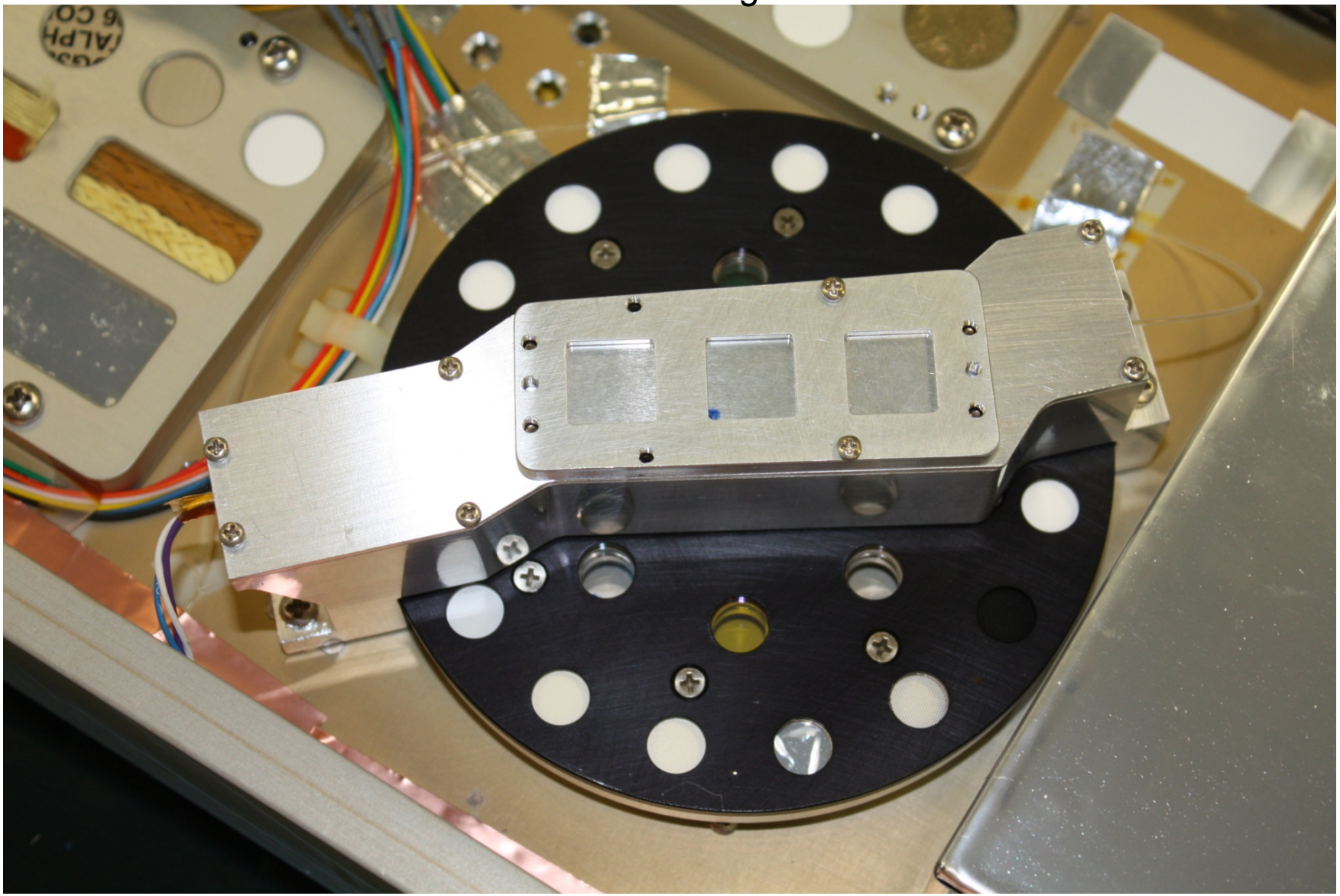
Wake Spectrometer - Boeing 2



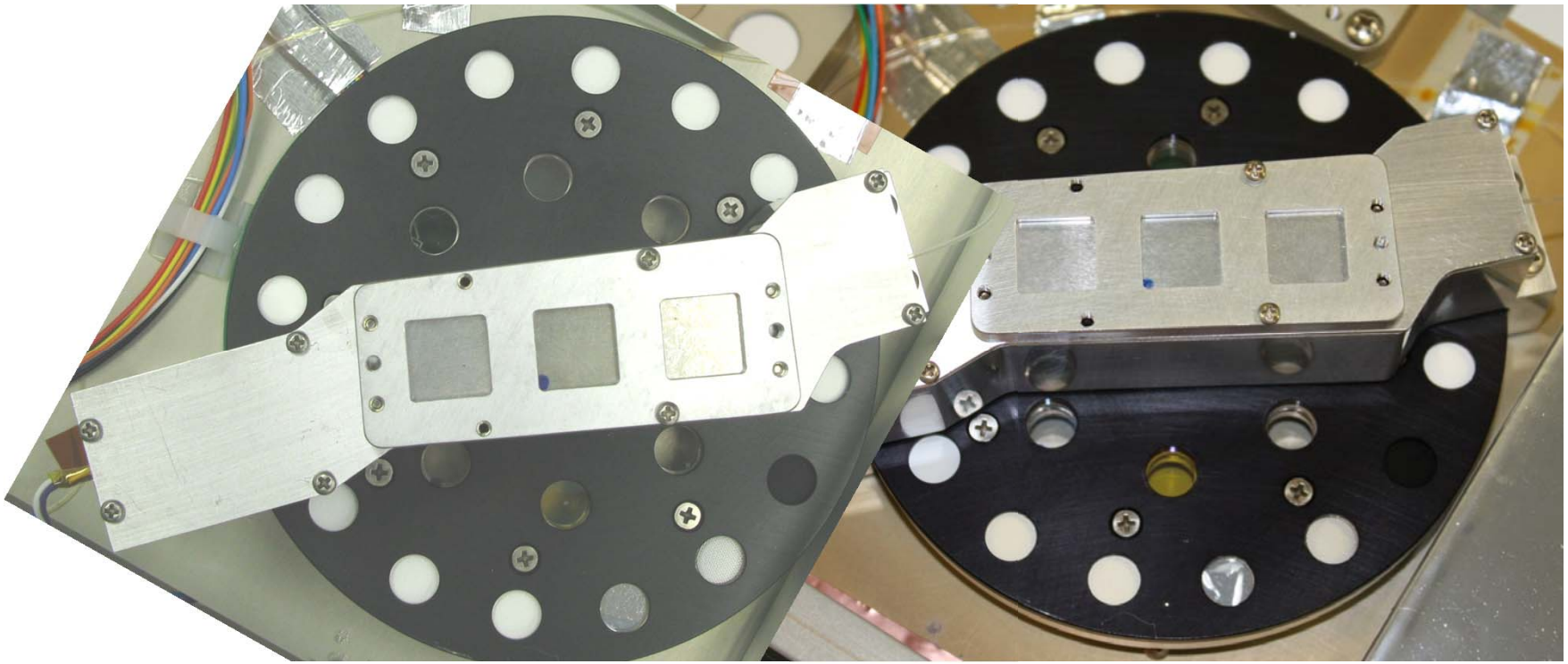
Location	Customer	Sample ID
53	Boeing	Control Fused Silica Bare
54	Boeing	SiO2 on Zr02
55	Boeing	AR on SiO2
56	Boeing	Al2O3 on ZrO2
57	Boeing	Control Al21O3 on SiO2
58	SDC	115-3118-1
59	Boeing	AR on SiO2
60	Boeing	K80326-M2 7" out
61	Boeing	Control Fused Silica Bare
62	MSFC	Control AZ Tek White AZ2000LSW
63	Boeing	Al2O3 on SiO2
64	Boeing	AR on SiO2 with AZ black backer
65	Boeing	AR on SiO2
66	MSFC	Control AZ Tek White AZW/LAll #2
67	Boeing	K80326-M2 5" out
68	Boeing	AR on SiO2
69	Boeing	K80326-M2 6" out
70	MSFC	Control AZ tek Black RM500IB #2
71	Boeing	AR on SiO2
72	Boeing	Al2O3 on SiO2 with AZ black back
73	Boeing	Al2O3 on SiO2
74	MSFC	MgF2/Al
75	MSFC	Stamet on black kapton
76	MSFC	Germanium on Black Kapton
77	Boeing	Fused Silica Bare
78	MSFC	Control AZ Tek

obscured locations

RAM 1 Post Flight



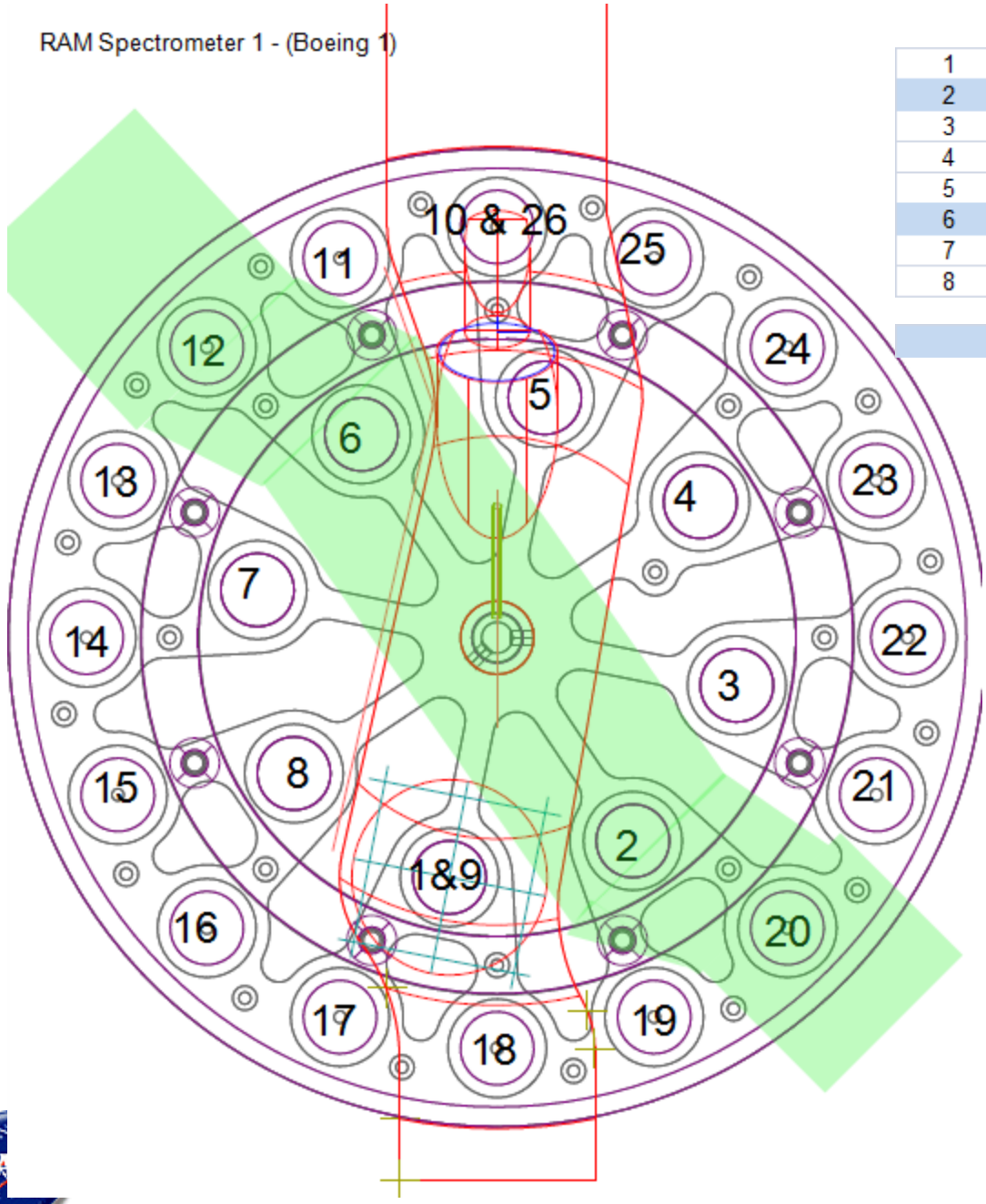
RAM 1 Pre vs Post Flight



Pre-Flight

Post-Flight

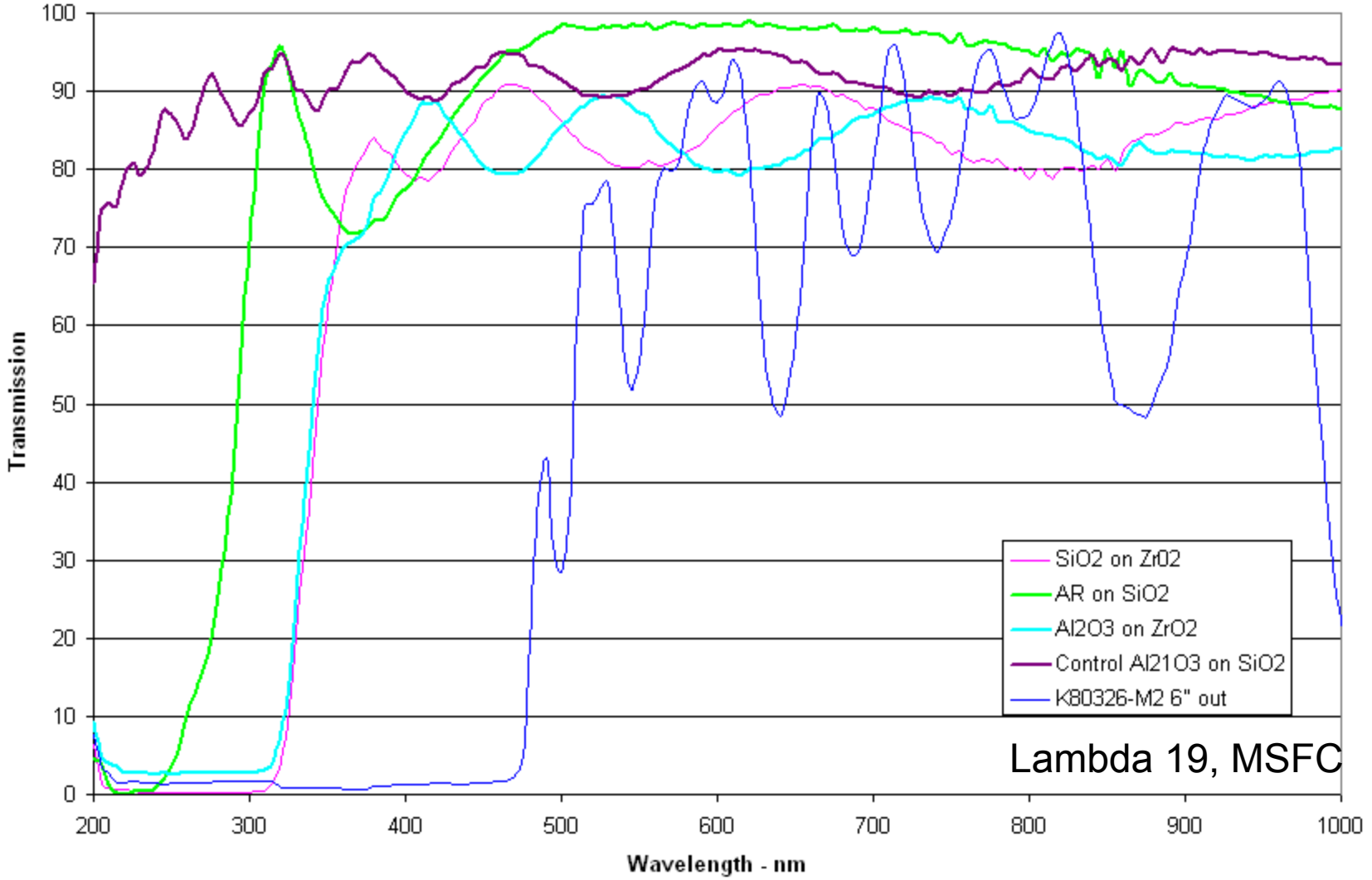
RAM Spectrometer 1 - (Boeing 1)



1	Boeing	Control Fused Silica Bare
2	Boeing	SiO2 on Zr02
3	Boeing	AR on SiO2
4	Boeing	Al2O3 on ZrO2
5	Boeing	Control Al21O3 on SiO2
6	SDC	115-3117-1
7	SDC	115-3116-1
8	Boeing	K80326-M2 6" out

obscured locations

PreFlight Transmission Spectra of Optical Coating Samples



Sample Selection for M7

- Space environment includes many factors that can influence performance of optical coatings
  - Low level contamination or erosion is most common effect
    - Changes in R,T and A
    - Spectral changes are not dominant, but easiest to measure
- Specific designs may enhance sensitivity to low level contamination
- M7 samples selected for simple design, highest contrast
  - To evaluate effects of the environment
  - To facilitate data collection/analysis from spectrometers

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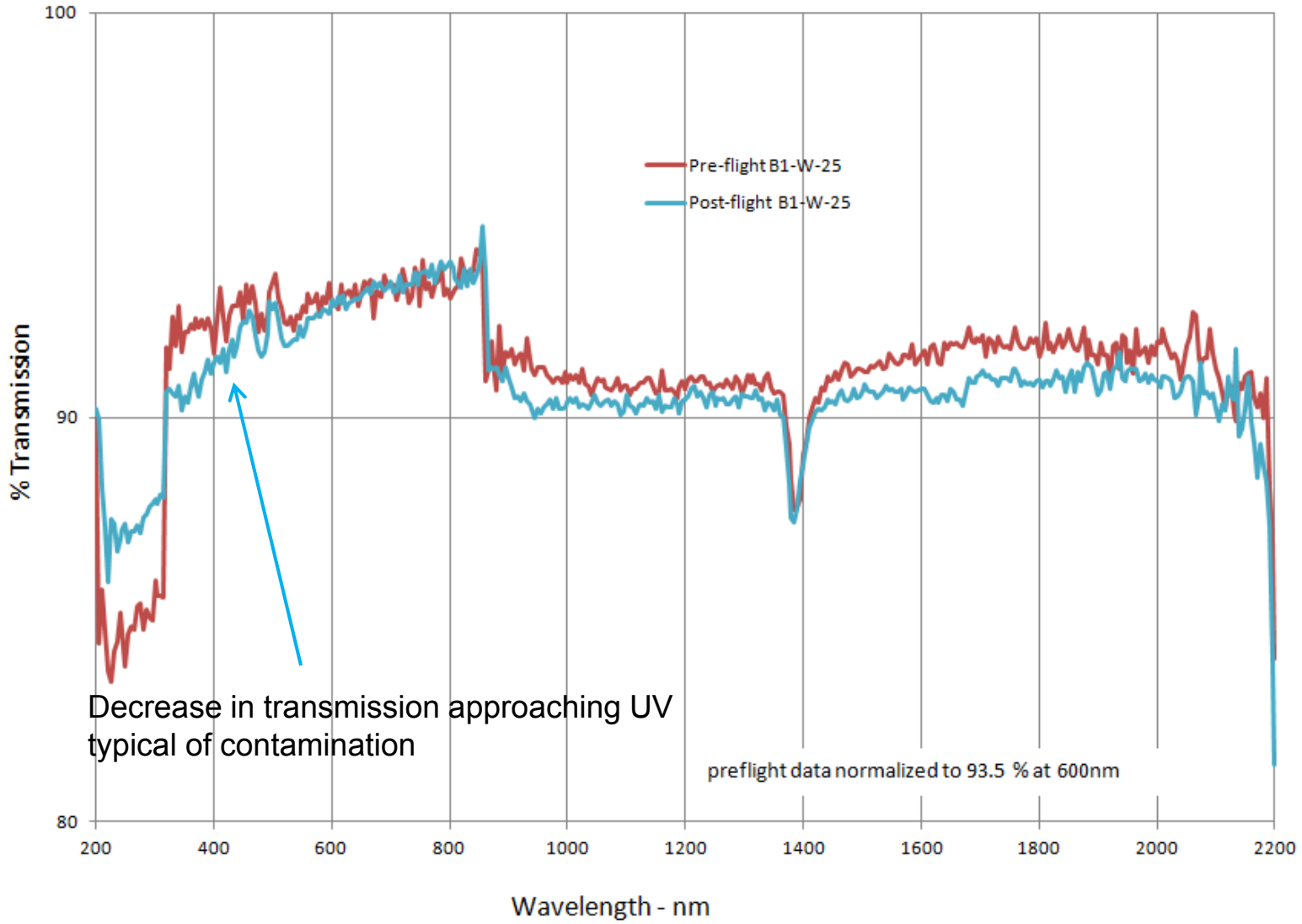
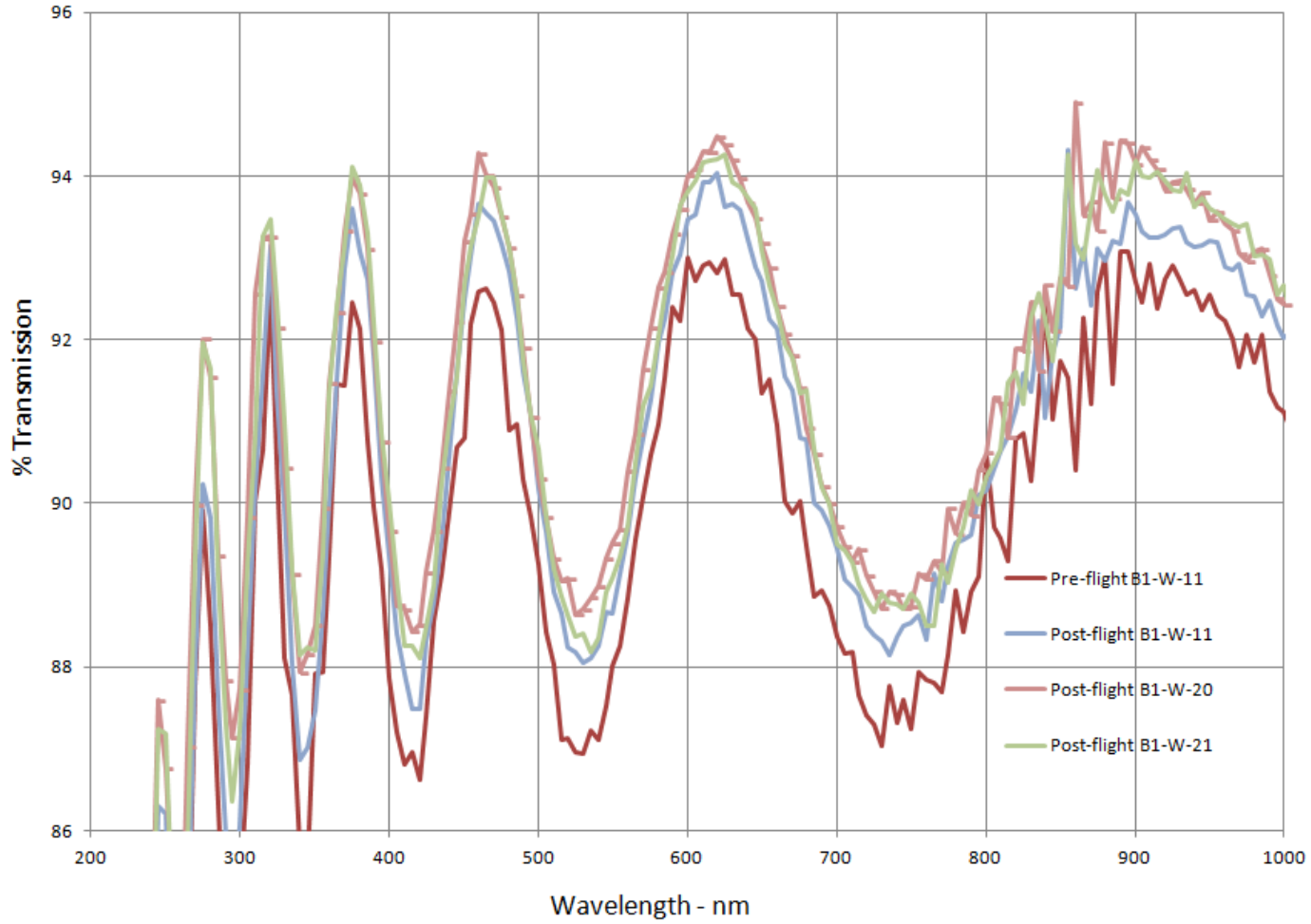
Uncoated Fused Silica

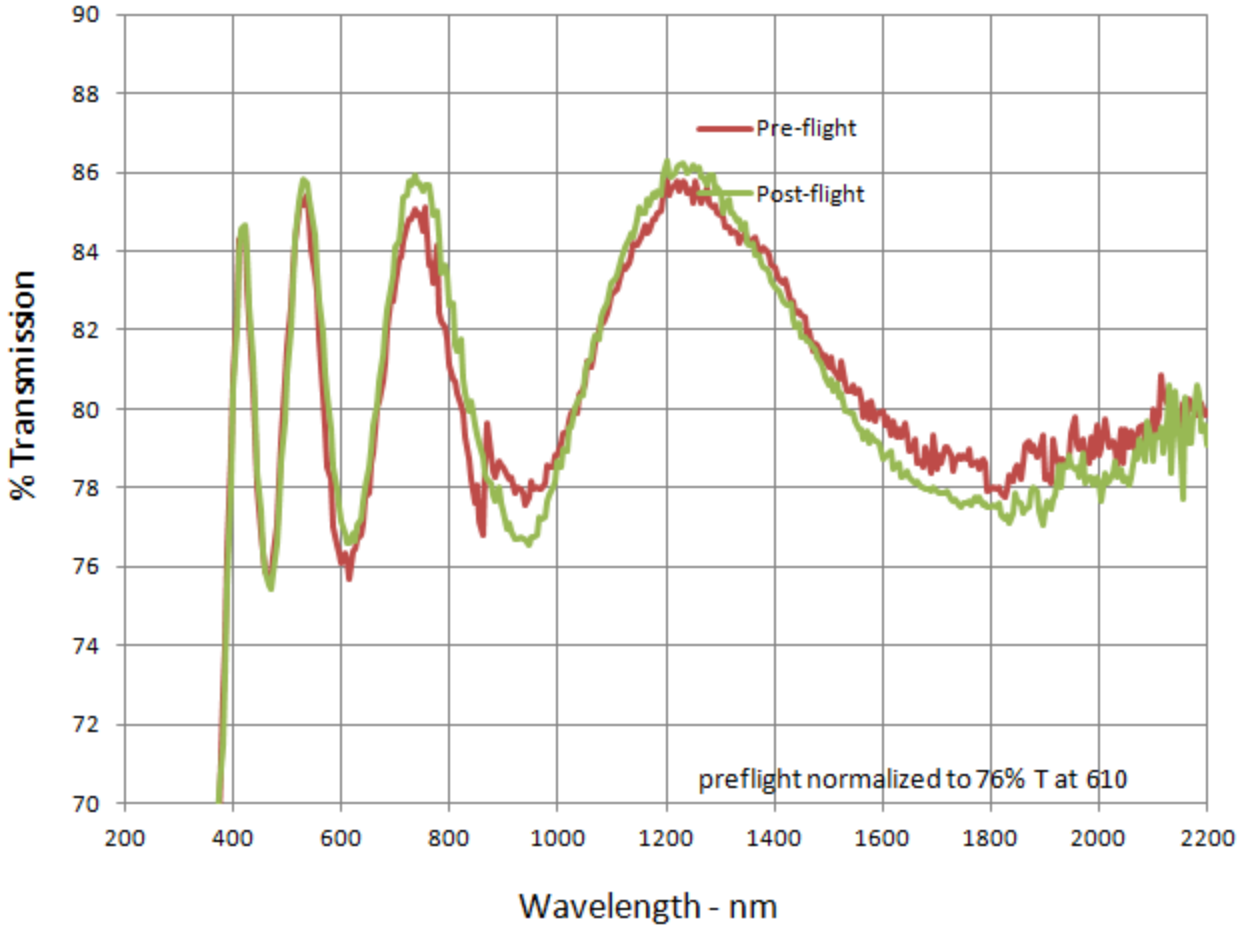


Al_2O_3 Coating on Fused Silica



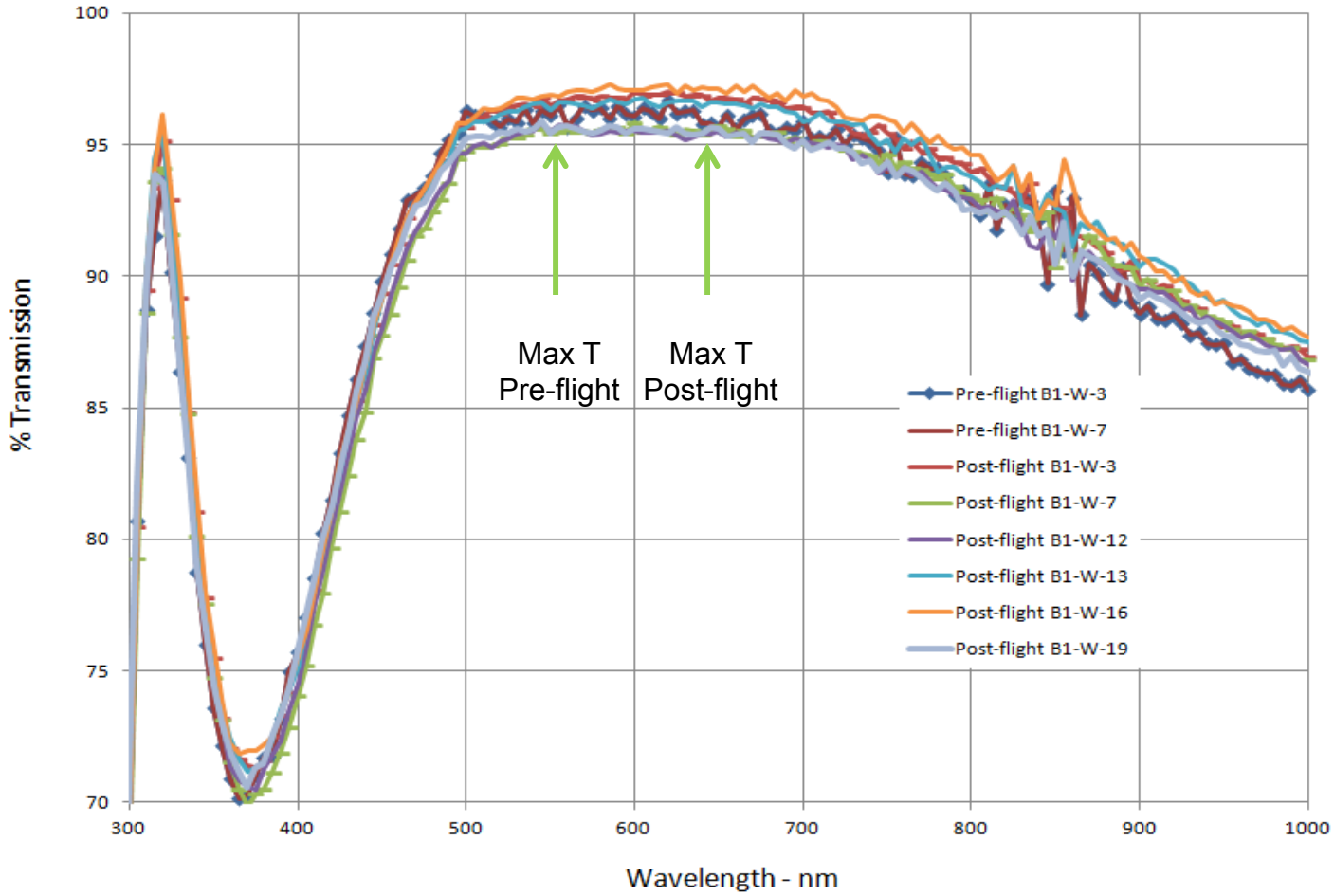
Increase in transmission to 94% may be attributed to 25nm of a polymer-like contaminant

Al_2O_3 Coating on ZrO_2



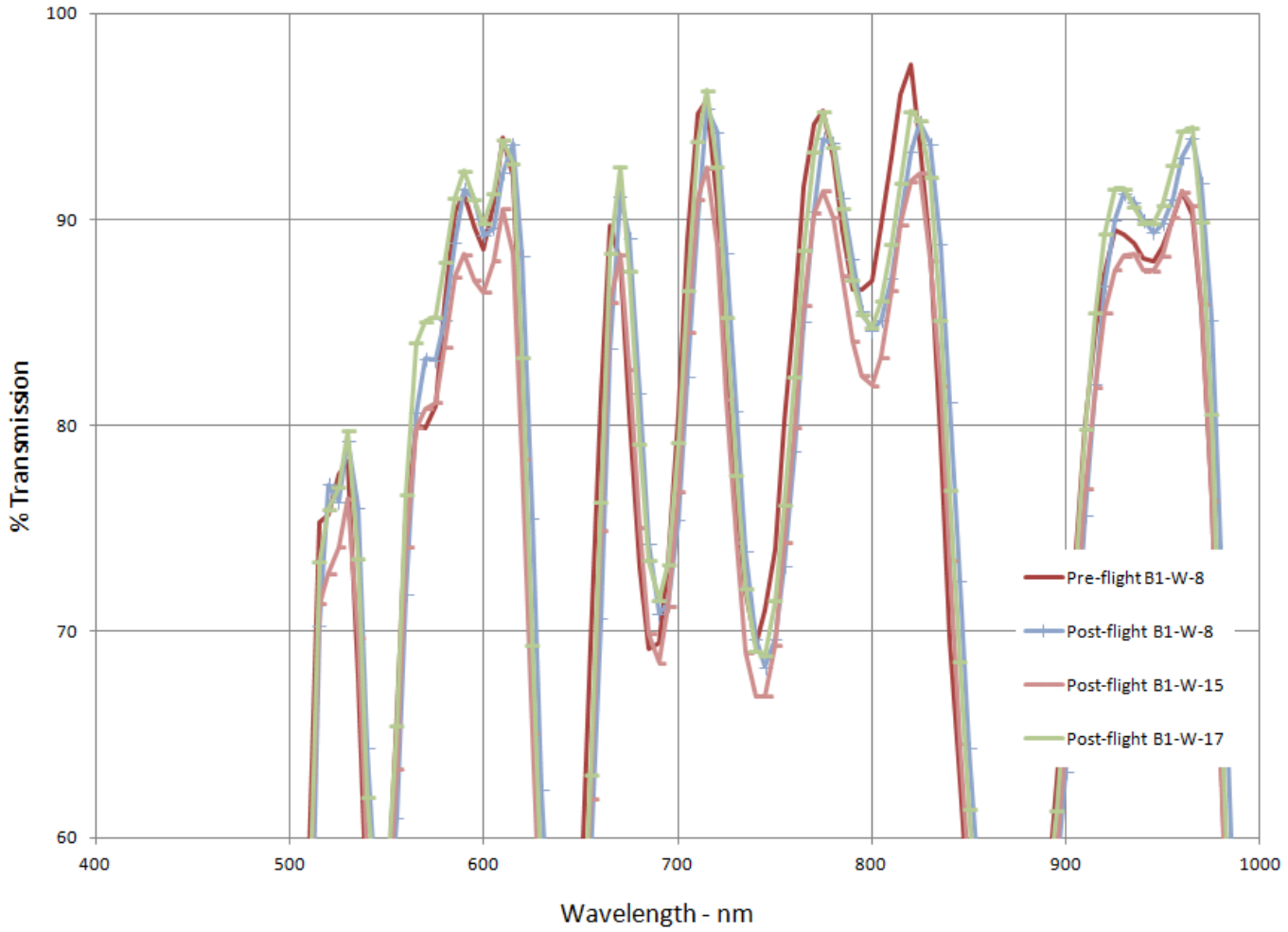
Increase in transmission may be attributed to 25-35nm of a polymer-like contaminant

AR Coating on SiO_2



Spectral shift of maximum transmission beyond 600nm consistent with 25-35nm of a polymer-like contaminant

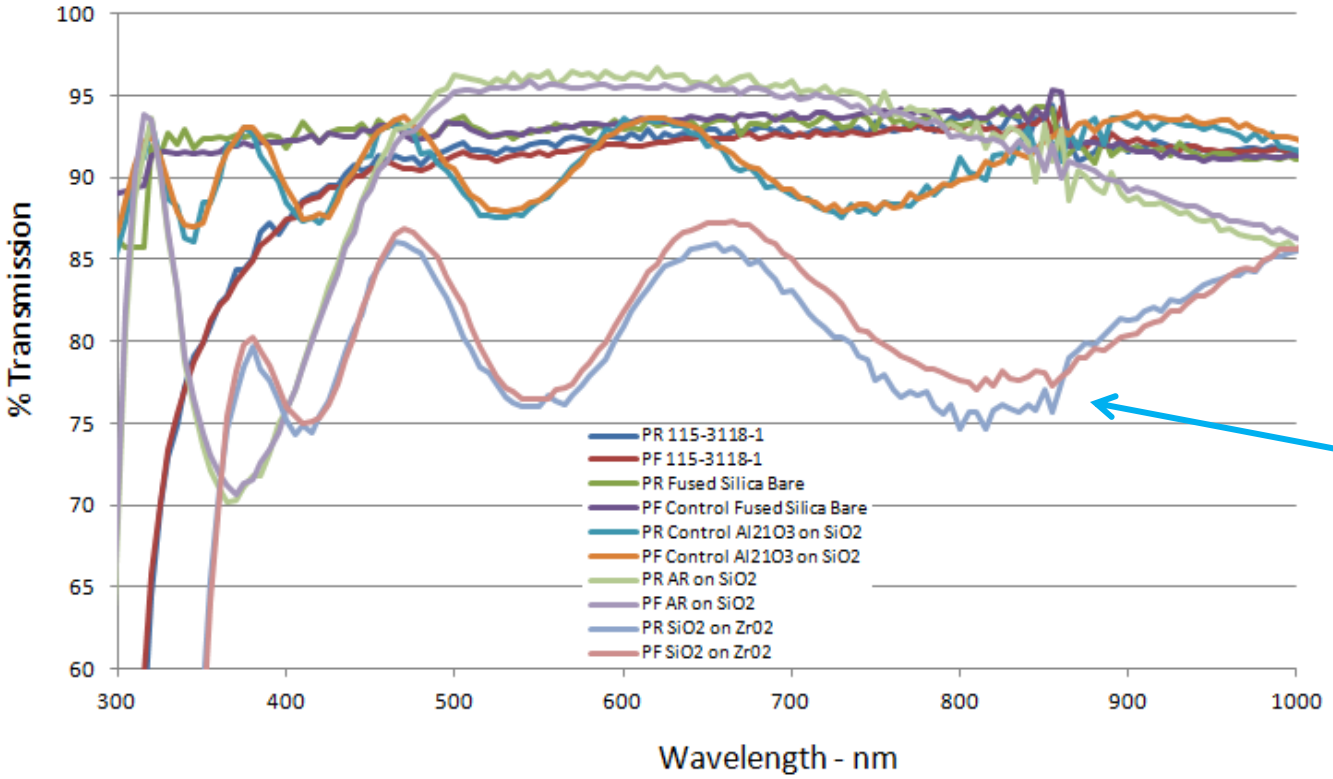
Multilayer ZnSe/ThF_4 HR Coating on SiO_2



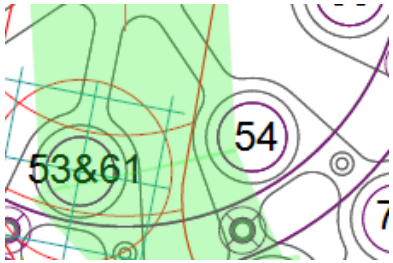
Spectral shift towards longer λ

- consistent with contamination layer on top of exposed ZnSe
- no evidence of AO erosion on wake side

Samples Obscured during the Flight – “Controls”



This sample partially obscured



Good correlation between before and after data – consistent with protection from exposure

Summary

- The MISSE 7 spectrometers were a significant step forward but didn't get to play
  - Miniaturization
  - Low power consumption
  - Speed
- Specific sample designs were chosen to enhance detection of low level contamination
- Data on the recovered optical samples from the wake carousel is completely consistent with the presence of a thin contamination layer
  - Some variation in amplitudes
    - Instrumentation
    - Sample size
    - Data is still reproducible
  - Measurement of samples that were shielded and never exposed show consistency in method